Polarized Λ-Baryon Production in pp

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In this talk, I analize the possibility of obtaining polarized Λ fragmentation functions from single polarized processes at RHIC.

Working within the framework of the radiative parton model, our starting point has been a fit to unpolarized data for Λ production taken in e^+e^- annihilation, yielding a set of realistic unpolarized fragmentation functions for the Λ. Taking into account the sparse LEP data on the polarization of $\Lambda's$ produced on the Z-resonance, we were able to set up three distinct "toy scenarios" for the spin-dependent Λ fragmentation functions, to be used for predictions for future experiments. We emphasize that our proposed sets can by no means cover all the allowed possibilities for the polarized fragmentation functions, the main reason being that the LEP data are only sensitive to the valence part of the polarized fragmentation functions. Thus, there are still big uncertainties related to the "unfavoured" quark and gluon fragmentation functions, making further measurements in other processes indispensable.

Under these premises, we have studied Λ production in semi-inclusive deep-inelastic scattering. Turning to spin transfer asymmetries sensitive to the longitudinal polarization of the produced Λ's, we have considered both $\vec{e}p \rightarrow \vec{\Lambda}X$ and $e\vec{p} \rightarrow \vec{\Lambda}X$ scattering. It turns out that in the first case SIDIS measurements at HERA (with spin-rotators in front of the H1 and ZEUS detectors) and at HERMES should be particularly well suited to yield further information on the ΔD_f^{Λ}: differences between the asymmetries obtained when using different sets of ΔD_f^{Λ} are usually larger than the expected statistical errors. In contrast to this, having a polarized proton target (or beam) does not appear beneficial as far as Λ production is concerned.

Then, we have also studied the production of longitudinally polarized Λ-baryons in single-spin $p\vec{p} \rightarrow \vec{\Lambda}X$ collisions at RHIC and HERA-$\vec{N}$ as a means of determining the spin-dependent Λ fragmentation functions. It is shown that a measurement of the rapidity distribution of the Λ's would provide an excellent way of clearly discriminating between the suggested sets of polarized Λ fragmentation functions. We also addressed the main theoretical uncertainties, which appear to be well under control.

As a final point, we have also done the analysis for the case of transversely polarized proton and Λ, a twist two observable which depends on both transverse parton distributions and transverse fragmentation functions. If Soffer's inequality is assumed to be saturated for both distributions at a very low scale, large assymetries are expected for this process.

POLARIZED FRAGMENTATION FUNCTIONS

- ONLY LEP data at the mass of the Z

UNpolarized $e^+e^- \xrightarrow[(Z)]{} \bar{\Lambda} X$ parity violating process

measure $A^\Lambda \propto \dfrac{g_3^\Lambda}{F_1^\Lambda}$ $\quad g_3^\Lambda \propto \Delta D_q - \Delta D_{\bar q}$ non-singlet (valence dist)

ONLY FIX $\sum e_q^2 (\Delta D_q - \Delta D_{\bar q})$ at $Q^2 = M_Z^2$

new assumptions

gluon distribution $\Delta D_g(\mu^2) = 0$

unfavored distributions $\Delta D_{\bar u}^{\Lambda} = \Delta D_u^{\bar\Lambda}(\mu^2) = \ldots = 0$

+ 3 Scenarios for $\Delta D_u, \Delta D_d, \Delta D_s$

- SCENARIO 1 ('NAIVE NRQPM'): $\Delta D_{s}^{\Lambda}(\mu^2) = z^\alpha D_s^\Lambda(\mu^2)$ $\quad \Delta D_u(\mu^2) = \Delta D_d(\mu^2) = 0$
- SCENARIO 2 ('Burkardt-Jaffe like') $\Delta D_s^\Lambda(\mu^2) = z^\alpha D_s^\Lambda(\mu^2)$

  $\Delta D_u^\Lambda(\mu^2) = \Delta D_d^\Lambda(\mu^2) = -0.2\ \Delta D_s^\Lambda(\mu^2)$
- SCENARIO 3 ('EXTREME BREAKING')

  $\Delta D_s^\Lambda(\mu^2) = \Delta D_u^\Lambda(\mu^2) = \Delta D_d^\Lambda(\mu^2) = z^\alpha D_s^\Lambda(\mu^2)$

- none of them can be eliminated yet $\begin{cases} \text{unfavored dist.} \\ \text{breaking of SU(3) in unpolarized F.F.} \end{cases}$
- they provide a way to compute other observables and to study sensitivity to pol. F.F.

PP collisions (only @ LO) (LONGITUDINALLY POLARIZED

$p\vec{p}_L \to \vec{\Lambda}_L X$ (to obtain $\Delta D_u^{\hat{}}, \Delta D_d^{\hat{}}$)

$$\frac{d\Delta\sigma^{p\vec{p}\to\vec{\Lambda}X}}{d\eta} \equiv \frac{d\sigma^{pp_+\to\Lambda_+X}}{d\eta} - \frac{d\sigma^{pp_-\to\Lambda_+X}}{d\eta}$$

$\eta > 0$ direction of $\vec{p}$

$$= \int_{p_T^{min}} dp_T \sum_{ff'\to iX} \int dx_1\, dx_2\, dz\; f^p(x_1,\mu^2)\; \Delta f'^p(x_2,\mu^2)\; \Delta D_i^{\Lambda}(z,\mu^2) \frac{d\Delta\sigma^{ff'\to iX}}{d\eta}$$

- p_T^{min} such that $z > 0.05$

  ENSURES :
  - APPLICABILITY OF PERT. QCD $\mu \sim p_T$
  - " " FRAG. FUNCTIONS
  - LARGER ASYMMETRIES $\frac{\Delta D}{D} \sim 20\%$

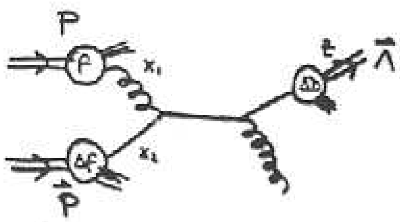
- two extreme KINEMATICAL REGIONS

  i) $\eta < 0$ small x_2, so $\frac{\Delta f}{f}$ very small $\Rightarrow$ $A \to 0$

  ii) $\eta > 0$ x_2 in the valence region, so larger $\frac{\Delta f}{f}$
  (ADVANTAGE WITH RESPECT TO "DOUBLE ASYMMETRIES $\vec{p}\vec{p}$
  and small x_1 (sea and unpol. gluons)

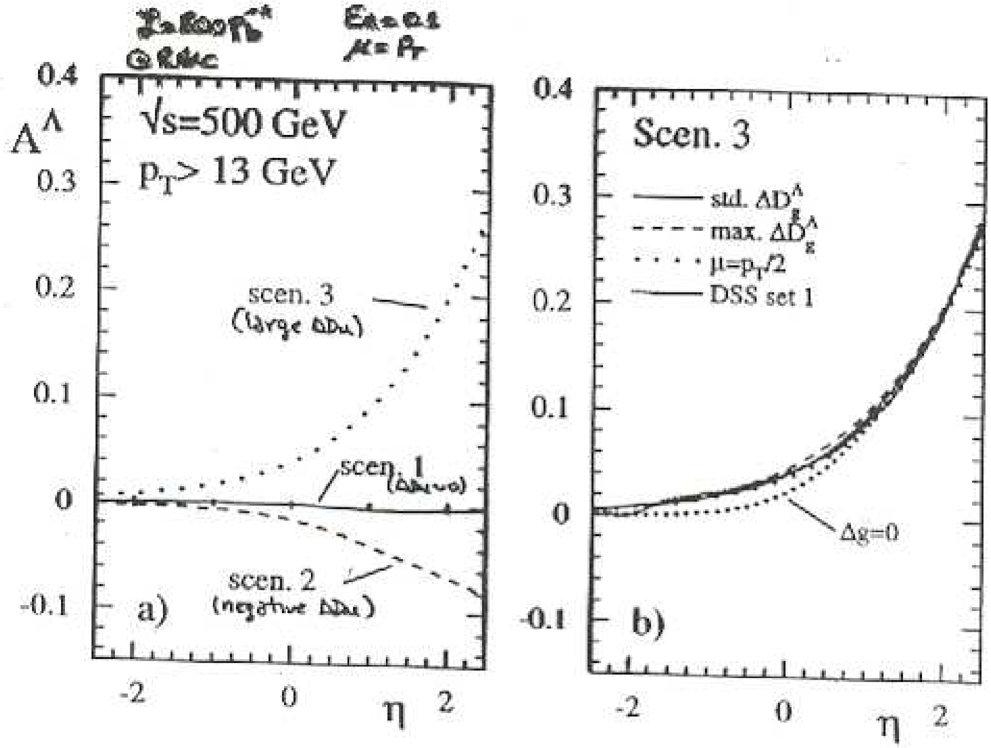
  Process dominated by

  $g\, \vec{q}_v \to \vec{q}\, g$
  $(x_1)\ (x_2)\quad (z)$



$\Delta u_v, \Delta d_v$ (KNOWN ~)

$\underline{\underline{\Delta D_u^{\hat{}}, \Delta D_d}}$



- SOURCES OF UNCERTAINTY
  - Scale dependence : important because of LO (and $\alpha_s^2(\mu^2)$)

    $\mu = \begin{matrix} p_T/2 \\ 2p_T \end{matrix} \Big\}$ large changes in $\Delta\sigma$ and σ
    – but cancel in the asymmetry

  - Dependence on Δq $\begin{cases} \text{GRSV std.} \\ \text{DSS set 1} \end{cases}$ – very small

    " " Δg $\begin{cases} \text{GRSV std.} \\ \Delta g = 0 \end{cases}$ " "

  - Dependence on $\Delta \hat{D}_g$ $\begin{cases} \text{std.} & \Delta \hat{D}_g(0.3\,\text{GeV}^2) = 0 \\ \text{max.} & \Delta \hat{D}_g(0.3\,\text{GeV}^2) = \hat{D}_g(0.3\,\text{GeV}^2) \end{cases}$

    – negligible

- SIMILAR SITUATION FOR $\sqrt{s} = 200$ GeV and $p_T > 8$ GeV ($\mathcal{L} = 240\,pb^{-1}$)

EXCELENT PROSPECTS FOR MEASURING $\Delta_L \hat{D}_u$ and $\Delta_L \hat{D}_d$

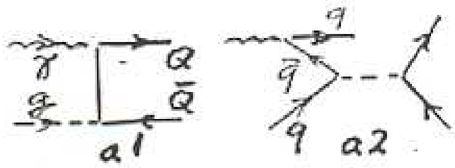
POLARZD PHOTOPR. OF HEAVY Q (OPEN) 2.

Leading order ($\alpha\alpha_s$)

(a1) Born

(a2) Resolved γ via
$\vec{q}\vec{\bar{q}} \to Q\bar{Q}$ $\quad \vec{g}\vec{g} \to Q\bar{Q}$

γ str. fn $\Delta F_{q/\gamma}$ $\quad \Delta F_{g/\gamma}$ known only theo.

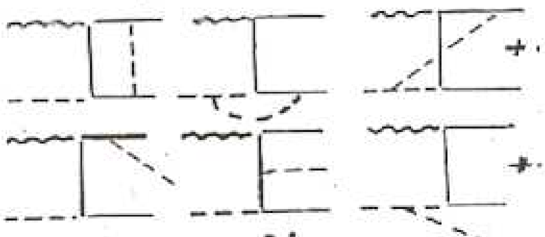


NLO ($\alpha\alpha_s^2$)

(β1) Loops & Brems

HARDEST part due to $m_Q \neq 0$.

Results for this.



β1

(β2) Subpr. $\vec{\gamma}\vec{q} \to Q\bar{Q}q$
no loops

Prelim. results : small

β2

Reg. (a2): Using. theoret. $\Delta F_{q/\gamma}, \Delta F_{g/\gamma}$ — Hassan & Pilkn

contribtns small in $\overline{MS}$ & phys. scales.

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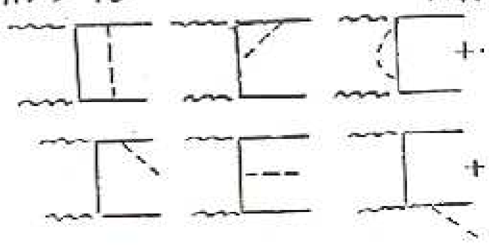
NOTE

Abelian part of (β1) provides HOC to
$\vec{\gamma}\vec{\gamma} \to Q\bar{Q}$

This of interest in itself in Higgs search when
$m_H < 2m_W$



PP collisions : transverse polarization

- UNKNOWN $\quad \Delta_T u \quad \Delta_T d \quad$ (information from Drell-Yan)

$\Delta_T D_u^{\Lambda} \quad \Delta_T D_d^{\Lambda}$

BUT A NICE LEADING TWIST (2) TRANSVERSE OBSERVABLE (LARGE ASYM ?)

- ESTIMATIONS USING SOFFER'S INEQUALITY for BOTH $\Delta_T q$ and $\Delta_T D$

$$|\Delta_T q| \leq \frac{1}{2}(q + \Delta_L q)$$

q : GRV
Δq : GRSV

$$|\Delta_T D| \leq \frac{1}{2}(D + \Delta_L D)$$

assuming saturation at a very small scale $Q_0^2 \sim 0.3\ GeV^2 \Rightarrow$
$\Rightarrow$ inequality valid at any scale $Q^2 > Q_0^2$

- in the saturation limit $\underline{D}$ dominates $\Rightarrow$ smaller differences between SCENARIOS

- even without imposing saturation one could expect asymmetries similar to LONGITUDINAL CASE

<u>Advantage with respect to</u> $p_T^\uparrow p_T^\uparrow$

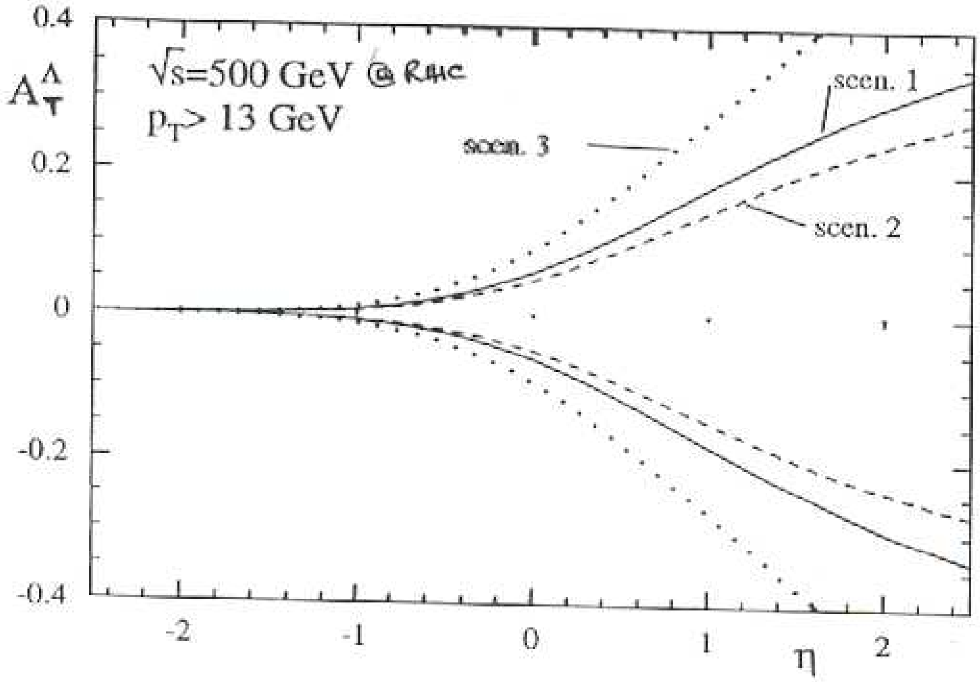
here dominates $\qquad g\, q_T^\uparrow \to g\, q_T^\uparrow \qquad$ large part. asym.

(according to $p^\uparrow p^\uparrow$ would mean $q_T^\uparrow \bar{q}_T^\uparrow \to gg$)

in $p_T^\uparrow p_T^\uparrow \Rightarrow \qquad q_T^\uparrow q_T^\uparrow \to q q \qquad$ small part. asym

$\mu = p_T$ $\quad\quad$ $p \vec{p}_T \to \vec{\bar{\Lambda}}_T X$

$\hat{S}_{p_T}$ and $\vec{S}_{\Lambda_T}$ have the same angle with respect to the scattering plane



• If $\Delta_L D$ known ⇒ good check for 'Double' Soffer's inequality